

CLAIMS

1. A liquid-jet head characterized by comprising a channel substrate which has pressure generation chambers formed therein and communicating nozzle orifices for discharging liquid droplets; and piezoelectric elements each of which is composed of a lower electrode, a piezoelectric layer, and an upper electrode and which are disposed on one surface of the channel substrate via a vibration plate, wherein at least pattern regions of the respective layers which constitute the piezoelectric elements are covered with an insulating film formed of an inorganic insulating material.
2. The liquid-jet head according to claim 1, wherein the insulating film is formed of an amorphous material.
3. The liquid-jet head according to claim 2, wherein the amorphous material is aluminum oxide (Al_2O_3).
4. The liquid-jet head according to claim 3, wherein the insulating film has a thickness of 30 to 150 nm.
5. The liquid-jet head according to claim 3 or 4, wherein the insulating film has a film density of 3.08 to 3.25 g/cm³.
6. The liquid-jet head according to any one of claims 3 to 5, wherein the insulating film has a Young's modulus of elasticity of 170 to 200 GPa.
7. The liquid-jet head according to any one of claims 3 to 7, wherein a lead electrode for the upper electrode is formed of a material containing aluminum as a predominant component.
8. The liquid-jet head according to any one of claims 1 to 7, wherein the sum of stress of the insulating film and stress

of the upper electrode is compressive.

9. The liquid-jet head according to claim 8, wherein stress of the insulating film and stress of the upper electrode are each compressive.

10. The liquid-jet head according to claim 9, wherein the upper electrode is formed of at least Pt.

11. The liquid-jet head according to claim 8, wherein stress of the insulating film is compressive, and stress of the upper electrode is tensile.

12. The liquid-jet head according to claim 11, wherein the upper electrode is formed of at least Ir.

13. The liquid-jet head according to claim 11 or 12, wherein stress σ of the upper electrode and that of the insulating film are each represented by the product $(\epsilon \times Y \times m)$ of Young's modulus of elasticity Y, distortion ϵ , and film thickness m, and stress σ_1 of the upper electrode and stress σ_2 of the insulating film satisfy the condition $|\sigma_1| < |\sigma_2|$.

14. The liquid-jet head according to any one of claims 1 to 13, further comprising an upper-electrode lead electrode extending from the upper electrode, wherein at least pattern regions of the respective layers which constitute the piezoelectric elements and the upper-electrode lead electrode are covered with the insulating film, except for regions facing connection portions of the lower electrode and the upper-electrode lead electrode, the connection portions being used for connection with connection wiring.

15. The liquid-jet head according to claim 14, further

comprising a lower-electrode lead electrode extending from the lower electrode, wherein the lower electrode is connected to the connection wiring via the lower-electrode lead electrode, and the pattern region containing the lower-electrode lead electrode is covered with the insulating film, except for regions of the upper-electrode lead electrode and the lower-electrode lead electrode facing the connection wiring.

16. The liquid-jet head according to claim 14 or 15, wherein the upper electrode and the upper-electrode lead electrode are formed of different materials.

17. The liquid-jet head according to any one of claims 1 to 16, wherein the piezoelectric layer and the upper electrode of each piezoelectric element extend to the outside of a region facing the corresponding pressure generation chamber so that a piezoelectric non-active portion is formed, and an end portion of the upper-electrode lead electrode on the side toward the upper electrode is located on the piezoelectric non-active portion and outside the pressure generation chamber.

18. The liquid-jet head according to any one of claims 1 to 17, wherein in a state in which the connection wiring is connected, the connection portions are covered with a sealing material formed of an organic insulating material.

19. The liquid-jet head according to any one of claims 14 to 18, wherein the insulating film includes a first insulating film and a second insulating film, the piezoelectric elements

are covered by the first insulating film except for the connection portion for connection with the upper-electrode lead electrode, the upper-electrode lead electrode is provided on the first insulating film, and at least the pattern regions of the respective layers which constitute the piezoelectric elements and the upper-electrode lead electrode are covered with the second insulating film except for regions facing the connection portions.

20. The liquid-jet head according to any one of claims 14 to 19, wherein the connection wiring includes a second upper-electrode lead electrode extending from the upper-electrode lead electrode, the second upper-electrode lead electrode is provided on the insulating film and is connected to the upper-electrode lead electrode at the connection portion, and a terminal portion to which drive wiring is connected is provided at a tip end portion of the second upper-electrode lead electrode.

21. The liquid-jet head according to any one of claims 14 to 20, wherein the piezoelectric layer and the upper electrode of each piezoelectric element extend to the outside of a region facing the corresponding pressure generation chamber so that a piezoelectric non-active portion is formed, and an upper-electrode-side end portion of the upper-electrode lead electrode which is connected to the upper electrode is located on the piezoelectric non-active portion and outside the pressure generation chamber.

22. The liquid-jet head according to any one of claims 14 to

21, wherein a protective plate having a piezoelectric-element-holding portion, which is a space for protecting the piezoelectric elements, is bonded to a surface of the channel substrate, the surface being located on the side toward the piezoelectric elements, and the connection portion of the upper-electrode lead electrode is provided outside the piezoelectric-element-holding portion.

23. The liquid-jet head according to any one of claims 1 to 22, wherein a protective plate having a piezoelectric-element-holding portion, which is a space for protecting the piezoelectric elements, is bonded to a surface of the channel substrate, the surface being located on the side toward the piezoelectric elements, the protective plate includes a flow passage for liquid to be supplied to the pressure generation chambers, the adhesive layer located on the flow passage side of the piezoelectric-element-holding portion is exposed to the interior of the flow passage, and a moisture permeable portion which enables permeation of water within the piezoelectric-element-holding portion is provided in a region other than the flow passage side of the piezoelectric-element-holding portion.

24. The liquid-jet head according to claim 23, wherein the moisture permeable portion is formed of an organic material.

25. The liquid-jet head according to claim 23 or 24, wherein the moisture permeable portion is provided on a portion of a bonding surface of the protective plate, the bonding surface being bonded to the channel substrate.

26. The liquid-jet head according to claim 23 or 24, wherein the moisture permeable portion is provided on an upper surface of the protective plate.
27. The liquid-jet head according to claim 25 or 26, wherein the moisture permeable portion is formed of an adhesive having a water permeability higher than that of an adhesive which constitutes the adhesive layer.
28. The liquid-jet head according to any one of claims 23 to 26, wherein the moisture permeable portion is formed of a potting material.
29. The liquid-jet head according to any one of claims 23 to 28, wherein the moisture permeable portion is provided in a region on a side of the piezoelectric-element-holding portion opposite the flow passage.
30. The liquid-jet head according to claim 23 or 24, wherein the moisture permeable portion is provided on the protective plate in each of regions outside the opposite ends of the row of pressure generation chambers.
31. A liquid-jet apparatus characterized by comprising the liquid-jet head according to any one of claims 1 to 30.
32. A method of manufacturing a liquid-jet head, comprising the steps of forming piezoelectric elements, each of which is composed of a lower electrode, a piezoelectric layer, and an upper electrode, on one surface of a channel substrate via a vibration plate, the channel substrate having pressure generation chambers formed therein and communicating nozzle orifices for discharging liquid droplets; forming an upper-

electrode lead electrode extending from the upper electrode of each piezoelectric element; forming an insulating film of an inorganic insulating material over the entirety of a surface of the channel substrate, the surface facing the piezoelectric elements; and patterning the insulating film such that at least connection-wiring connection portions of the lower electrode and the upper-electrode lead electrode are exposed, and the insulating film is left in pattern regions of the respective layers of the piezoelectric elements and the upper-electrode lead electrode, except for the connection portion.

33. The method of manufacturing a liquid-jet head according to claim 32, wherein in the step of patterning the insulating film, a portion of the insulating film within a predetermined region is removed by means of ion milling.

34. The method of manufacturing a liquid-jet head according to claim 33, wherein the method includes, after the step of patterning the insulating film, a step of bonding a protective plate to a surface of the channel substrate, the surface facing the piezoelectric elements, the protective plate including a piezoelectric-element-holding portion for protecting the piezoelectric elements and a flow passage for liquid to be supplied to the pressure generation chambers, wherein in the step of bonding the protective plate, an adhesive is applied to the protective plate such that a space portion is left in a portion of a region surrounding the piezoelectric-element-holding portion, except for a region

located on the side toward the flow passage, the protective plate is bonded to the channel substrate, and the space portion is sealed by a material having a water permeability higher than that of the adhesive so as to form a moisture permeable portion through which water within the piezoelectric-element-holding portion permeates.